MANSPEAKER, Jr.

# Improvement of Illinois Highways

Civil Engineering

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# IMPROVEMENT OF ILLINOIS HIGHWAYS



BY

LEWIS VINTON MANSPEAKER, JR.

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## THESIS

FOR THE

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

LEWIS VINTON MANSPEAKER, JR.

ENTITLED IMPROVEMENT OF ILLINOIS HIGHWAYS

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Civil Engineering

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# I M P R O V E M E N T

of

# I L L I N O I S  H I G H W A Y S

by

Lewis Vinton Manspeaker, Jr.

Champaign, Illinois

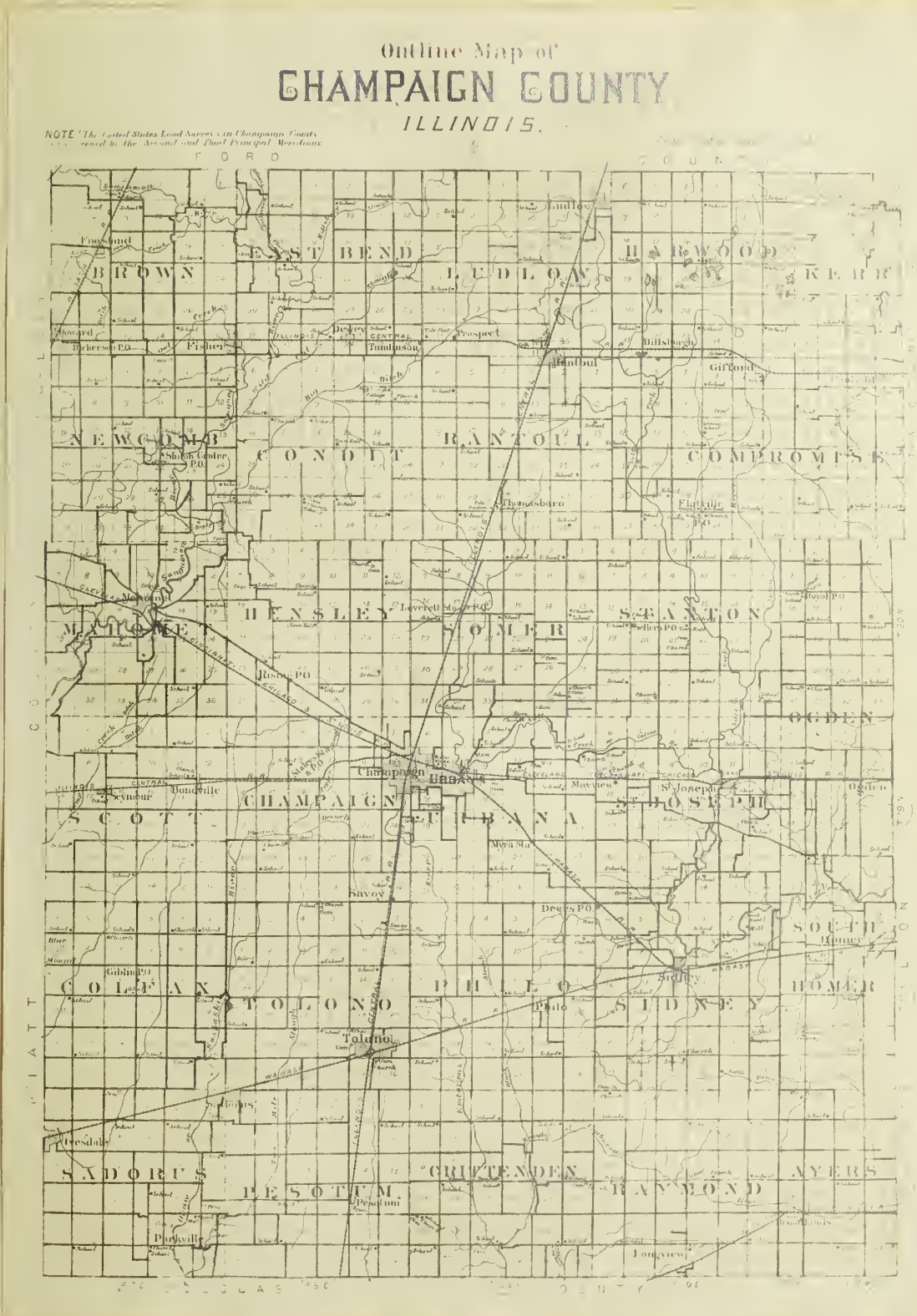
June, 1909

# C O N T E N T S

# I M P R O V E M E N T  O F  I L L I N O I S  H I G H W A Y S

## INTRODUCTION

In the past few years, the citizens of the State of Illinois have begun to recognize the growing importance of our highways. Not many years ago, the conditions were such that the roads did not demand attention other than the cleaning of the side ditches once a year. Now on account of the increase in traffic and a general desire on the part of the farmers for advancement, nearly every one seems to be wide awake to the necessity of improving the roads. Therefore in this thesis, the writer will present the conditions which he finds in Champaign County, a good representative of the state, and will suggest and explain some advised methods of constructing and maintaining these improvements.




Reduced from the map of Champaign County taken from the plat book, with the roads made more prominent.

## PRESENT CONDITIONS

Champaign County is situated in the east central part of the state within 90 miles of Springfield, and fairly represents the state in topography, amount of production, and traffic.

Topography.-

In general, Champaign County is flat and has a gradual slope to the south and west. Ludlow, on the north, is one of the highest points on the Illinois Central Railroad between Chicago and Cairo, being about 770 feet above sea-level. Parkville, on the south, is in the lowest part of the county, about 660 feet above sea-level. This gives an average slope of 2.5 feet per mile or 0.047 per cent. There is a network of small creeks that flow into the Sangamon River on the west, Salt Fork on the east, and the Embarras and Kaskaskia on the south; all of which afford good outlets for drainage, and which are sufficiently able to take care of the mean annual rainfall of 38 inches. However, owing to the very small slope of the area drained and the imperviousness of the subsoil, water will often stand in some of the lower places until it evaporates. Thus artificial drainage must be employed to dry the land sufficiently for agricultural purposes and road building.

The soil is a rich black vegetable mold or loam which varies from 18 inches to 2 or more feet beneath the surface. It is underlaid, to a depth of from 6 to 100 feet, with yellow clay which is not impervious to water. Below this bed is a stratum of impervious blue clay which abounds in pockets of sand and gravel, from which most of the drinking water is obtained. The surface soil of loam consists chiefly of clay, silicious sand, and carbonate of lime, with more or less oxide of iron, magnesium and various other salts, and also decayed vegetable and animal matter. The clay in the mixture renders it adhesive and the sand makes it porous. With the addition of water, with which it readily mixes, the soil becomes very fertile and is especially adapted to the growing of corn; but when vehicles and horses travel over muddy roads, the mixture soon becomes so kneaded as to form a semi-liquid mass, which together with the stiff mud renders it practically impassable for traffic.

Crops.-

Champaign County has an area of 632 000 acres, a little less than 100 square miles. Its most important product is corn, the yield being the largest of any one county in the state. Table I presents the acreage and yield of the different crops for 1908. Table II presents the dairy product sold in 1908.

TABLE I

CROP YIELD FOR 1908

| Crop | Area in Acres | Yield per Acre | Total Yield in Bushels | Price | #Value of Crop |
|---|---|---|---|---|---|
| Corn | 209 648 | 36 | 7 547 328 | $0.56 | $4 226 504 |
| Oats | 122 520 | 26 | 3 185 520 | 0.44 | 1 401 629 |
| Hay | 21 122 | 1 3/4 tons | 36 963 tons | 7.00 | 236 741 |
| Wheat | 423 | 23 | 9 816 | 0.85 | 8 344 |
| Rye | 42 | 22 | 924 | 0.80 | 739 |
| Barley | 10 | 29 | 290 | 0.53 | 153 |
| | | | | | $5 874 110 |

TABLE II

DAIRY PRODUCT FOR 1908

| Product | Gallons Sold | Price per Gallon | Value |
|---|---|---|---|
| Milk | 114 620 | $0.20 | $22 924 |
| Cream | 12 841 | 0.65 | 8 347 |
| | | | $31 271 |

# The value of the crop was obtained from the prevailing price August 1, 1908.

The above data, which were obtained from the reports of the Illinois State Board of Agriculture for August 1, 1908, and December 1, 1908, show the importance of the county from an agricultural standpoint and the immense products, the total value of which is $5 905 381, that must be hauled to the different towns.

Traffic.-

The traffic about the City of Champaign has been observed from four different stations under the direction of the State Highway Commission. The figure below shows the number of vehicles passing a certain point on the Bloomington Road just outside of Champaign for a period of seventeen months.

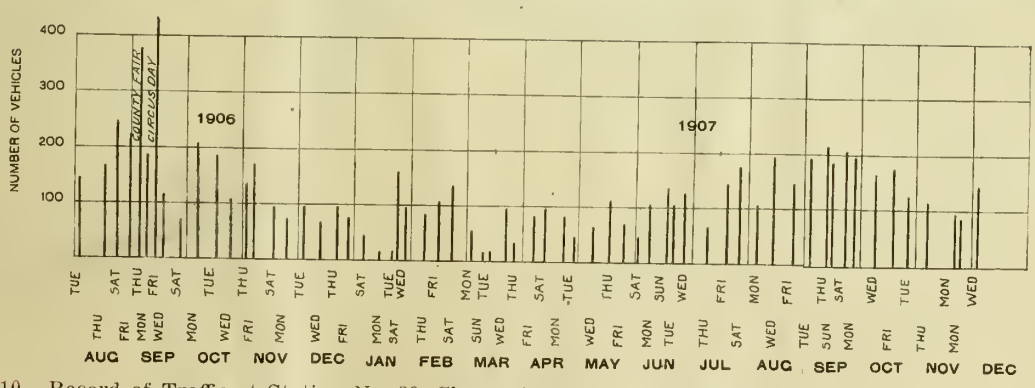



Fig. 10. Record of Traffic at Station No. 29, Champaign, Champaign County.

Taken from the report of the Illinois State Highway Commission for 1907.

If the traffic were on roads that were little affected by the conditions of the weather, the diagram would show a greater uniformity. To better illustrate the variations shown here, the following table will give the average number of vehicles passing per day for each season of the year.

TABLE III

NUMBER OF VEHICLES PASSING PER MONTH

| Season | 1st Month of Season | 2nd Month of Season | 3rd Month of Season | Average for 3 months | Mean |
|---|---|---|---|---|---|
| Winter | 99 | 52 | 67 | 72 | 73 |
| Spring | 104 | 44 | 74 | 74 | |
| Summer | 82 | 103 | 127 | 104 | 135 |
| Fall | 146 | 189 | 157 | 167 | |

Computed from data obtained from the report of the Illinois State Highway Commission for 1907.

Table III gives a mean value of 73 vehicles passing during the winter and spring and 135 during summer and fall. This shows that there is 53 per cent more traffic from June to December than from December to June. Consequently, it seems

fair to conclude that on account of the winter weather, the highways are in a bad condition; some days almost impassable. This is a good argument in favor of road improvement.

Economic Advantages of Road Improvement.-

The advantage of road improvement from an economic standpoint is important. Farmers usually consider this question from the money point of view, and wish to be assured that the returns will justify the expenditure. The farmer's experience in road improvement is confined to results and not to theory. Consequently, he can not foresee the benefits derived from a proposed plan when supported by theoretical data. Some of these data are misleading. For instance, reports have been sent out by the Government showing how many millions or billions of dollars are wasted annually by bad roads; but these reports take into consideration the entire road mileage in the United States and are based upon guesses, some of which are very far from the actual facts. The data as to the cost of hauling the crops to market under various conditions of the roads, are also not worth very much to the farmer. He does not pay for the hauling in money, but considers the strain on his own horses in going to town and the number of trips that can be made per day. Notwithstanding these exaggerated statements, there are economic considerations that will appeal to the farmer. In the first

place, better roads decrease the cost of trasportation; at some seasons a great deal, at others not so much. A comparison of the ease with which a heavy load is hauled over a road in good condition and the difficulty of hauling over one badly cut up and frozen, will make this evident. In the second place, there is a wider choice of the market places, where advantage can be taken of the non-uniformity of the prices offered by the elevators. Road improvement also permits the marketing to be done when the prices are most favorable, and the telephone enables the farmer to obtain this information. For instance, if he should learn in the morning by means of the telephone that the market price is the probable maximum for the season, he can take advantage of this high price by hauling his product to the elevator the same day, provided the roads will permit. This is the general custom. However, in Champaign County the oats and wheat yield is hauled directly after harvesting to the elevator, where it is held until the farmer wishes to sell, paying storage while awaiting a high price. The corn, our principal product, is left on the farm until the market price and the roads are the most favorable. The price may be very high, but the roads impassable, and the farmer wishes to sell yet can not until the roads are open to traffic, when he pays dearly for the delay.

In this thesis, the suggestions for road improvement

will not require the expenditure of any more money than is included within the present tax rate; therefore further discussion of the economic advantages of road improvement is not necessary.

Social Advantages of Road Improvement.-

Although the economic advantages of road improvement are very important, the progress along social and educational lines should be considered the most important. The improvement of the highways should be regarded as a convenience, such as modern bath-rooms, illuminating gas, telephones, etc., which nearly every progressive farmer has. It permits social intercourse among the farmers themselves and those living in town. It facilitates the rural free delivery which brings news of the daily happenings from points of interest; and finally, makes the consolidation of rural schools possible and practical which in turn increases their economy and efficiency. A full enjoyment of these advantages will result in making the occupation of the farmer a more pleasant and profitable business and his home life more delightful.

Road Administration.-

Champaign County is under the general township organization, i. e., is governed by a board of supervisors, one from each township. There are also three highway commissioners

elected in each township, who have complete control over the roads and bridges in that township, and who levy the tax for their construction and maintenance. In 1908, there was a levy of $0.50 on each $100.00 worth of taxable property, amounting to $103 980.41 not including a poll-tax of $1.50 on 1 063 men living outside of the towns and cities. This poll-tax can be paid in cash or worked out at the rate of $1.00 per day, but it has been the custom in this county for the farmers to cut the weeds along the roads and in this way to work out their tax. Consequently, only a very small amount of money has ever been realized from this source. With the 1 830 miles of highways in the county, there is an average of $56.82 allowed per mile for expenses, approximately 50 per cent of which is spent on the roads. This seems high for the construction and maintenance of bridges and earth roads, but it includes the laying of some expensive drains and the replacing of several bridges where the creeks were dredged.

## EARTH ROADS

Earth roads will be considered in detail because: first, practically all the roads in Champaign County are earth (only five miles out of a total of 1 830 miles, are surfaced

with gravel); second, they are the cheapest in first cost; and third, their improvement is the first logical step in obtaining better highways. The native soil must be thoroughly drained and the surface so protected as to resist the climatic conditions in the best possible way. Then, after this has been accomplished, should the resurfacing of the roads with gravel, broken stone, etc., be considered; but not before.

Construction.-

Drainage: Drainage is by far the most important consideration in road building, for without it no road no matter how much improved can remain good any length of time. Especially is this true in loamy soil when it is made soft by the autumn rains and rendered almost impassable by the following frosts and thaws. Drainage can be divided into three different systems; surface drainage, side-ditch drainage, and underdrainage.

By surface drainage is meant the removal of the water from the surface of the roadway. Its object is to carry off the water from the surface as freely and quickly as possible. This is accomplished by "crowning" the road, that is, by making it higher in the center, and keeping the crown smooth so that there will be no obstruction to the flow. If the road is kept free from ruts and holes, less crown will be necessary, but too small a slope will prevent the rapid removal of the

water. On the other hand, if the crown is too great, the traffic will be concentrated in the center of the road, which will become hollowed out and sometimes the side slopes will be washed into the ditches. Thus it is a difficult matter to state just how much of a slope is necessary, but it is generally agreed that it should not be more than 1 inch to a foot, or less than 1/2 inch to a foot. On steep grades, it should be a little greater to prevent the water from taking a diagonal course in reaching the side ditches. The surface drainage is principally a matter of maintenance, so the form given to the surface of the roadway should be that most easily obtained by the road drag. There is considerable difference of opinion as to whether it should be the arc of a circle or the meeting of two planes at the center, but such accuracy is not practical. The figures shown below give a very good standard for the cross-section of earth roads in this county. The width of clear roadway for state roads is 30 feet and for all others 24 feet.

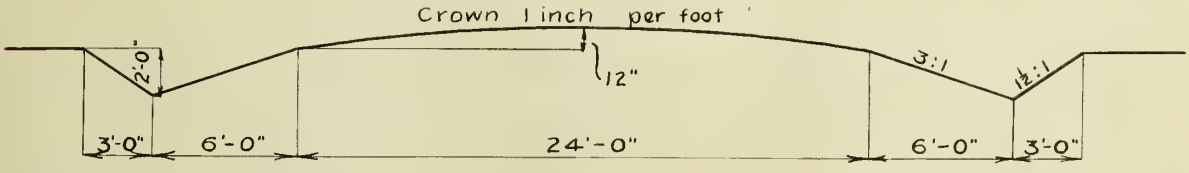



Fig.1. SECTION IN CUT.

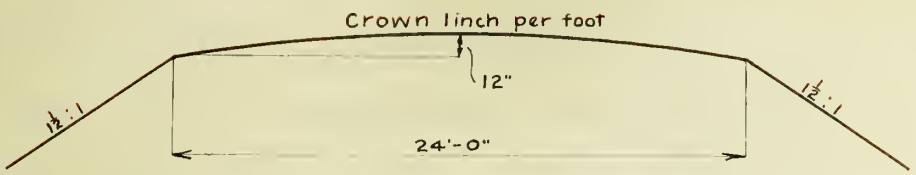



Fig. 2. Section in Fill.

When the water flows off of the roadway, it collects in the side ditches, which should have a uniform grade and a free outlet into some stream. In a slightly rolling country, such as is found in Champaign County, these ditches frequently have no outlet and the water accumulates at the foot of the slope where it remains until it evaporates or seeps into the tile drain beneath. This is very detrimental to the roads and in some cases has been successfully overcome by constructing a catch-basin 3 feet in diameter with an 18-inch grating and at a depth of approximately 1 1/2 feet below the bottom of the tile which drains the subsoil (see next article). The object for this extra depth is to prevent the clogging of the drain by the silt carried down with the water. These catch-basins are cleaned once or twice a year. In order to convey the water into the catch-basins from the opposite side ditch, it is necessary to construct a culvert, generally of sewer pipe or concrete, 15 to 24 inches in diameter

depending upon the amount of water to be carried.

Underdrainage serves two purposes, namely, to assist the ditches in carrying off the surface water, and to lower the ground-water level. In land around Champaign, the ground water is generally within four or five feet of the surface, and in the winter and spring it rises somewhat higher. When the frost leaves the ground, the water is released and there it remains, making the roadway very soft. Vehicles will cut it up and the horses' hoofs work it until the road can no longer be used. If there is underdrainage, the water, being set free when thawing takes place, will be carried off by the tiles, and leave the roadway solid. This also enables the ground to dry more quickly and produces a firm foundation for traffic.

There are two methods of underdraining a road: first, by one line of tile; and second, by two lines, one on either side. These are usually placed in the side ditches about 3 to 3 1/2 feet deep. The ground water takes a slope of 4 per cent under the most adverse circumstances, according to the tests made by the Illinois Agricultural Experiment Station, and this can be taken as a maximum slope. If one line of tile is used, the area above ABC in Fig. 3 will be drained, and with two lines, the drainage area is that above ABD, if laid at the same depth. Thus by two lines of tile, the triangle CBD is drained in addition

to the area above ABC. However, this does not make any material difference as in most cases where one line is to be used, the tile will be laid about a foot deeper, so that this triangular area will be included. If the tile is of sufficient size, of ample depth, and is properly laid, one line will give adequate drainage for all road purposes although two lines will give the desired results more quickly. Sometimes, however, the tile is so small or so poorly laid that one line is not sufficient. In this case two lines are generally used in order to make sure of good drainage.

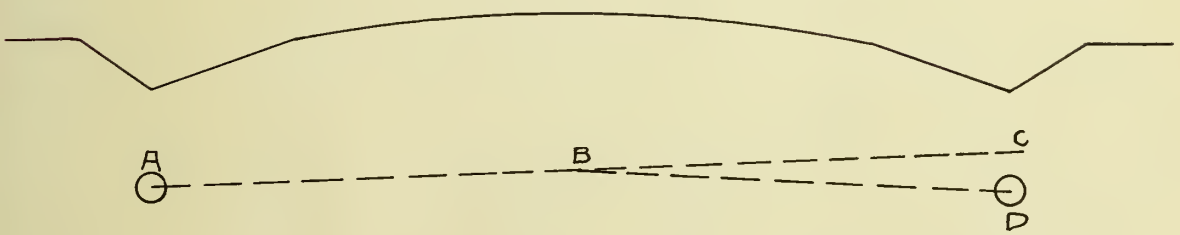



Fig. 3.

The tile used for road drainage is the straight, soft-burnt, porous tile, usually employed for agricultural purposes; and should be uniformly burned, round, smooth on the inside, and cut off square on the ends. Table IV gives the cost of lay-

ing drain tile per foot of depth per rod, at the present time in Champaign County, and the cost per 1000 free on board at the factory, subject to a discount of $6.00 per car.

TABLE IV

COST OF DRAIN TILE AND OF LAYING

| Size in Inches | Price per 1000 f.o.b. at Factory | Cost of Laying per Foot per Rod |
|---|---|---|
| 4 | $ 15.00 | $0.10 - 0.125 |
| 5 | 21.00 | |
| 6 | 27.00 | 0.15 |
| 7 | 36.00 | |
| 8 | 48.00 | 0.18 |
| 10 | 66.00 | |
| 12 | 95.00 | 0.20 - 0.22 |
| 15 | 165.00 | |

Drain tile is laid in this county per foot of excavation per linear rod, and this method has proved much more economical and efficient than that by day labor. The grade at which the

tile is laid generally follows the slope of the ground, the usual slope being from 1 1/2 to 2 inches in 100 feet, with a minimum of 1/2 inch to 100 feet. When a line of tile is to be laid on a road, it has been the custom here to consult with the farmers who own adjacent land, and give them the option to enlarge the proposed size of tile at their own expense, if they wish to connect their farm drains with it. This has been carried out in a large number of cases, and results in clean tile of ample size, and at the least possible cost.

To sum up, drainage is a permanent improvement which requires little or no maintenance, and which quickly shows the benefit; probably, there is no way in which money can be expended on earth roads to a better advantage than in laying tile drains. After this has been considered, the next step is the use of a scraping grader.

Use of the Scraping Grader: Since the roads are nearly all permanently located and only a few miles of new ones have been opened in the last five years, the discussion on the operation of the grader will be limited to the straightening and cleaning up of the roads, which is done once each year. The object is to fill the ruts, free the roads from weeds, etc., and to produce a surface such as is shown in Fig. 1, page 13. Thus, it is immaterial which make of a machine is used, provided that it will

obtain the desired results in an economical way. The grader that is used to a large extent in Champaign County, is the Road King which is made by the J. D. Adams Company of Indianapolis, Indiana, and which costs about $300.00. The picture below gives a very good idea of the Road King grader working on a typical section.

This make of grader is very efficient for heavy work, such as the cutting of new side ditches and filling of old ones which were not in the proper location. It has been found more economical, however, to plow furrows where the side ditches will be located. This cuts the sod for the grader and gives a straight line for it to follow. The plow also cuts down the

knolls quickly and with little cost compared with the grader which otherwise would be used. Such cuts as shown in the following picture are frequently found in straightening a road. "A" represents the new line for the side ditch, and "B", the old line worn deep by the erosion of the water.


For road work of a lighter character, a scraper manufactured by the Western Wheeled Scraper Company of Aurora, Illinois, is used to good advantage. The cutting edge or blade is so placed that the loose earth is quickly carried off to the side, while the Road King seems to roll the earth. The first picture shown below gives the Western scraper in operation, and the second, shows a road finished by this scraper.

The cost of operation is practically the same for either type, because it requires three teams and three men (two drivers and one operator), and the work accomplished is approximately the same. A good day's work is three miles of finished roadway; and the cost of a team and man is $4.00, making a total of $12.00 or $4.00 per mile of road.

Maintenance.-

After the roads have been graded, the side ditches cleaned, and the crown made smooth, they should be kept as nearly as possible in this condition throughout the year. To do this for a reasonable amount of money, is a difficult task; but the solution of the problem lies in the intelligent use of the road drag.

Road Drag: There are many types of road drags, the main object of which is to move the earth toward the center of the road and to raise it gradually above the surrounding level, at the same time filling all mud-holes and ruts into which traffic will pack the loose earth. Among the most common types of drags are the split-log drag and the plank drag.

The split-log drag is the type generally used, and Mr. D. Ward King of the United States Office of Public Roads is its most widely known advocate. The best material for its construction is red cedar; however, red elm or walnut when thoroughly dried are excellent, but box elder, soft maple, or even willow

are preferable to oak, hickory or ash. The log should be 7 or 8 feet long, about 10 inches in diameter, and carefully split down the middle. The heaviest and best slab should be selected for the front, since the hardest work is done by it. Fig. 4 gives a working drawing of the split-log drag.

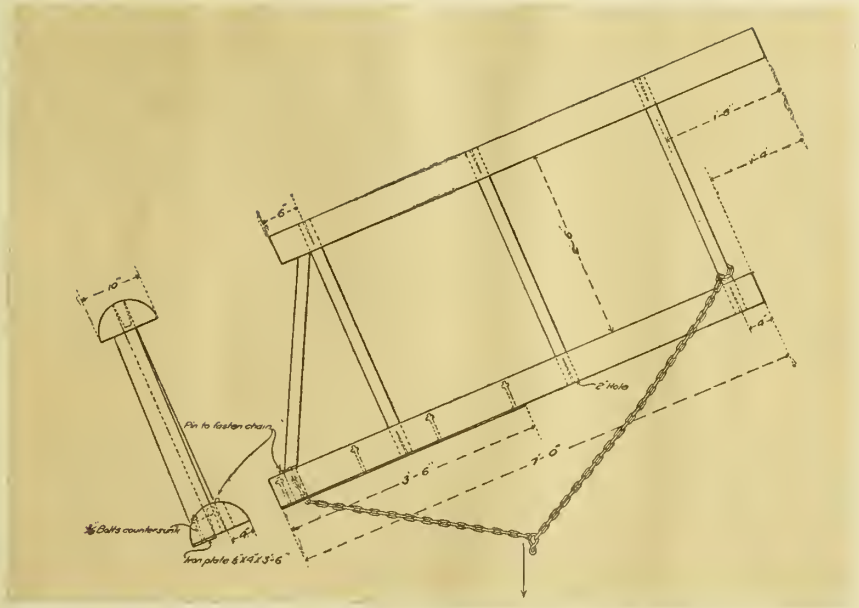



Fig. 4 Plan and Elevation of the Split-Log Drag. Taken from Farmers Bulletin No. 321.

In construction, care must be taken in holding the augur plumb to bore the holes in order that the stakes shall fit properly. The stakes should taper gradually to the ends and should be fastened in place by wedges only. The bolts holding

the iron cutting edge, should have flat heads, be countersunk, and be placed so that the iron plate will be 1/2 inch below the slab at the ditch end. The ordinary trace chain is strong enough and should be wrapped around the rear stake, then passed over the front slab which allows the earth to drift by the face of the drag, and should be fastened by means of a pin through a link at the opposite end of the slab. A platform of 1-inch boards held together by 3 cleats, should be placed on the stakes between the slabs so that the end cleats will not rest on the cross stakes. The boards should be spaced at least an inch apart so that any earth which falls over the front slab, may sift through to the roadway.

Drags are often made of planks instead of logs, but their construction is similar to that of the split log except the strengthening of the planks along their middle by a 2 x 6 inch strip as is shown in Fig. 5.

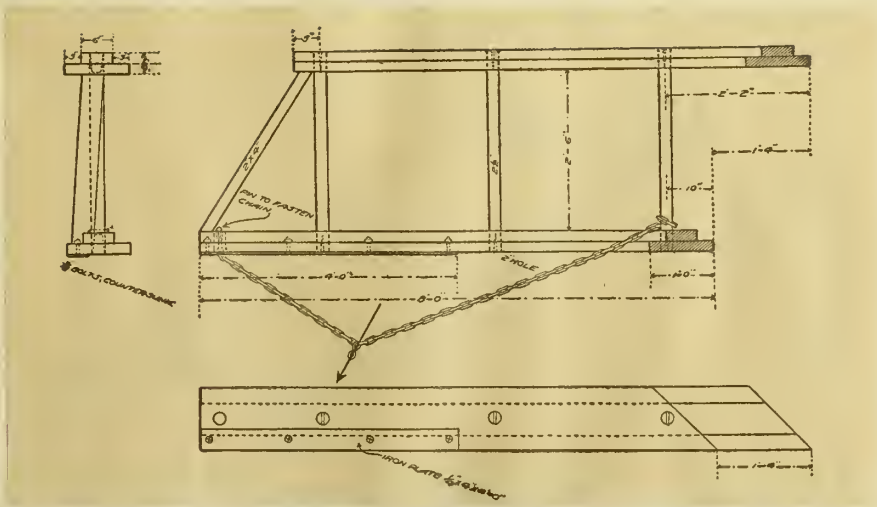


Fig. 5. Plan, Front and Side Views of Plank Drag.
Taken from Farmers Bulletin No. 321.

The road drags described above have the same general characteristics since they have two cutting edges and require two horses in their operation. Mr. T. M. Lyman, for several years Highway Commissioner in Champaign Township, has been using a drag of his own design which departs somewhat from this principle, and which has proved very satisfactory to him in the work in his district. It consists of one cutting edge followed by a board laid flat to smooth the surface, and the use of an evener because four horses are required. The advantages claimed are: First, that only one cutting edge is necessary; second, that somewhat heavier work can be done; third, that a better crown can be made; and fourth, that more miles of road can be dragged in a day, and although four horses are used, the cost per mile is somewhat less than with other drags. The following picture shows the chief differences to the common type.

The successful operation of a drag involves two principles which when thoroughly understood and intelligently applied, make road maintenance very simple. The first concerns the length and position of the hitch, and the second deals with the position of the driver on the drag. For ease of operation, the earth should move smoothly along the face of the drag and give comparatively light draft to the team. Under ordinary circumstances, this is accomplished by fastening the clevis or snatch link far enough toward the blade end of the chain to force the unloaded drag to follow the team at an angle of 45 degrees. Nevertheless, conditions are encountered that require special attention, such as a seepy spot or a flat place several rods long. The distance from the drag at which the team is hitched affects the depth of the cutting; shortening the hitch tends to lift the front slab from the ground, and lengthening it causes the blade to cut more deeply. This can be regulated by adjusting the chain at the end where it is fastened by a pin.

For instance, if small weeds are to be cut or a furrow of earth is to be removed, the doubletree should be attached rather close to the hitch end which will cause the drag to move at a greater angle. The driver should stand with his weight on the extreme forward end of the front slab which will swing the drag back to the proper angle and cause the blade to plow. This hitch requires slow and careful driving in order to prevent the

drag from tipping forward. If the blade should plow too deeply, however, as is the case in a wet spot, the driver should shift his weight toward the back slab; similarly, if he wishes to drop a load of earth into a low place or mud-hole, he steps quickly away from the hitch end.

The drag does the best work when the soil is moist, but not sticky, at which time the earth moves freely along the faces of the slabs. If the roadway is very badly rutted or full of holes, it may be well to use the drag once when the ground is slushy. This applies particularly before a cold spell in winter when it is possible to have the roadway freeze smooth. Some authors advise the use of the drag when the roadway is very soft because when clayey loam is mixed with water and is thoroughly worked it becomes remarkably tough and impervious, and when compacted in this condition it is extremely hard. In order to receive full benefit from dragging a soft roadway, it must not be opened to traffic until it has thoroughly dried. This can be accomplished by dragging say the middle 10 or 12 feet, allowing vehicles to travel only on the sides. These in turn can be dragged as soon as the middle section has dried. The picture below, however, shows the common method of using a split-log drag on a road just after a rain.

THE SPLIT-LOG DRAG IN USE ON A COUNTRY ROAD.

Taken from the Technical World Magazine for January, 1909.

There is little available data on the cost of maintenance of earth roads by dragging; but there is no doubt as to its economy either in first cost or in operation. The average drag costs about $9.00 for the material and labor, but this may be reduced to a very small amount in money if it is made from material usually found on a farm. An estimate of the cost of maintenance in Champaign County by the use of the road drag, is from $1.50 to $2.00 a mile for the year. This use of the drag will produce a road "like a race-track".

## CONCLUSION

The popularity of the road drag led the state to pass a law in 1907, which gives the highway commissioners the power to contract with tenants or land owners adjoining the road, and which allows them the privilege either to have the roads dragged during December, January, February and March at a rate not to exceed $1.00 a mile for two round trips, a width of 20 feet, or to have the work done during the summer at a rate of $0.75 a mile. This law does not compel the commissioners to make contracts, nor can those who drag the road voluntarily, unless a contract has been previously made, force the commissioners to pay for such work. The law, however, has aroused great interest throughout the state, and has resulted in the construction and operation of approximately 15 000 road drags.

By an intelligent and faithful use of the drag, an earth road can be improved almost beyond belief. It will become smooth, serviceable, and free from ruts, weeds and mudholes. There also will be less dust and mud than on roads not maintained in this manner. Dust on an earth road is caused by the breaking up under traffic of the upturned edges of ruts and hoof prints. Consequently, if the surface is smooth after each rain and the road dries hard and even, no edges are exposed to crushing and the only dust which forms is that due to the actual

wear of the road surface. This is slight because of the strength with which the particles of clay cohere. On the other hand, mud will be reduced because of the compactness of the earth, and because of the surface drainage due to a well kept crown. All of these things and many others of less importance can be procured with the expenditure of very little money and labor; but on account of the general attitude of the people in Champaign County, road improvement will be gradual.

The new type of earth road. The material common black DIRT. The DRAINAGE secured by side ditches free from weeds and debris, and by the crown. The drainage system will be complete when the tile (piled along the road) have been laid to carry off the ground water. The DRAG is responsible for the smoothness and the rounding shape. We think this road will make the property on each side more desirable.

Taken from Bulletin 1, Vol. III, of the Iowa Highway Commission Report